Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

M.Tech. Scheme (1st semester) (Design Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
MET701	Concepts of Engineering Design	PC	3	0	0	0
MET702	Modeling and Analysis	PC	3	0	0	0
MET703	Vibration Analysis and Control	PC	3	0	0	0
MET704	Advanced Mechanical Engineering Design	PC	3	0	0	0
MEP705	CAD/CAE Lab	PC	2	0	0	3
MEP706	Vib. Lab	PC	2	0	0	3
MEP707	Design lab	PC	2	0	0	3
	Total Credits		**18**			

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

M.Tech. Scheme (2nd semester) (Design Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
	Programe / Open Elective-1	PE	3	3	0	0
	Programe / Open Elective-2	PE	3	3	0	0
	Programe / Open Elective-3	PE	3	3	0	0
	Programe / Open Elective-4	PE	3	3	0	0
	Programe / Open Elective-5	PE	3	3	0	0
	Programe / Open Elective-6	PE	3	3	0	0
	Total credits		**18**			

List of Program Elective Courses

Course Code	Course Title	Course Category	Credits	L	T	P
MET711	Computer Aided Fluid Dynamics		3	3	0	0
MET712	Advanced Finite Element Methods		3	3	0	0
MET713	Optimization Methods In Engineering Design		3	3	0	0
MET714	Computer Aided Design		3	3	0	0
MET715	Composite Materials And Mechanics		3	3	0	0
MET716	Robotic Engineering		3	3	0	0
MET717	Rotor Dynamics		3	3	0	0
MET718	Design For Manufacture		3	3	0	0
MET719	Dynamics of Multibody Systems and Applications		3	3	0	0
MET720	Fracture Mechanics		3	3	0	0
MET721	Design of Mechanisms		3	3	0	0

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

M.Tech. Scheme (3rd semester) (Design Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
MES741	Seminar		4	0	0	4
MED752	Dissertation		16	0	0	16
	Total credits		**20**			

M.Tech. Scheme (4th semester) (Design Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
MED 743	Dissertation		16	0	0	20
	Total credits		**16**			

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : ***MET701***
Course Name : **Concepts Of Engineering Design**
Credit (L-T-P) : **3 (3-0-0)**

COURSE OUTCOMES

CO1: Understand the broad scope of design engineering and evaluate/analyse products, systems through various engineering tools
CO2:Recognize the main drivers for design engineering & Attain problem solving skills through modeling/simulation and optimize design.
CO3:Ability to do material selection based on economy and value analysis. Develop understanding on DFM/DFA.
CO4:Apply some basic concepts and methods from design engineering to explore creative solutions to clearly defined real world problems.

Syllabus

Design Fundamentals: Importance of design- The design process-Considerations of Good Design – Morphology of Design –Organization for design– Computer Aided Engineering – Designing to codes and standards – Concurrent Engineering – Product and process cycles – Technological Forecasting – Market Identification – Competition Bench marking.
Customer Oriented Design & Societal Considerations: Identification of customer needs- customer requirements- Quality Function Deployment- Product Design Specifications- Human Factors in Design – Ergonomics and Aesthetics. Societal consideration - Contracts – Product liability – Protecting intellectual property – Legal and ethical domains – Codes of ethics - Ethical conflicts – Environment responsible design-future trends in interaction of engineering with society.
Design Methods: Creativity and Problem Solving –Creativity methods-Theory of Inventive Problem Solving(TRIZ)– Conceptual decomposition-Generating design concepts-Axiomatic Design – Evaluation methods-Embodiment Design-Product Architecture-Configuration Design- Parametric Design. Role of models in design-Mathematical Modeling – Simulation – Geometric Modeling –Rapid prototyping- Finite Element Analysis– Optimization – Search Methods.
Material Selection Processing and Design: Material Selection Process – Economics – Cost Vs Performance – Weighted property Index – Value Analysis – Role of Processing in Design – Classification of Manufacturing Process – Design for Manufacture – Design for Assembly – Designing for castings, Forging, Metal Forming, Machining and Welding – Residual Stresses – Fatigue, Fracture and Failure.
Probability concepts in Design for Reliability: Probability – Distributions – Test of Hypothesis
– Design of Experiments – Reliability Theory – Design for Reliability – Reliability centered Maintenance-Robust Design-Failure mode Effect Analysis.

Books:

1. Dieter, George E., “Engineering Design - A Materials and Processing Approach”, McGraw Hill, International Editions, Singapore, 2000.
2. Pahl, G, and Beitz, W.,” Engineering Design”, Springer – Verlag, NY. 1984.
3. Ray, M.S., “Elements of Engg. Design”, Prentice Hall Inc. 1985.
4. Suh, N.P., “The principles of Design”, Oxford University Press, NY.1990.

Karl T. Ulrich and Steven D. Eppinger “Product Design and Development” McGraw Hill Edition 2000

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : ***MET702***
Course Name : ***Modeling and Analysis***
Credit (L-T-P) : **3 (3-0-0)**

Course Description

This course would introduce the post-graduate or senior undergraduate engineering students to the concepts of the theory of elasticity/ advanced mechanics of materials. The concepts learned will be applied to the solution of engineering problems for understanding the behaviour of elastic solids under given loads. In addition, the students will understand the limitations of the results obtained and the validity of assumptions made in the Elementary Mechanics of Materials/ Solid Mechanics.

Course Outcomes

At the end of the course the student will be able to:

- **CO1:**Understand and explain the mathematical and physical foundations of the continuum mechanics of solids, in light with the limitations of the elementary course on mechanics of materials.
- **CO2:**Explain and apply the advance concepts of theory of elasticity including various measures of deformation, strain, and stress.
  Formulate, derive and explain the equilibrium equations, constitutive equations, boundary conditions and compatibility equations and hence, have the ability to pose and solve boundary value problems involving deformable solids.

Syllabus

Theory of Linear Elasticity: Stress, Equation of Motion, Symmetry of Stress Tensor, Transformation of Stresses, Principal Stresses, Principal Directions, Strain, Rotations, Compatibility Equations, St. Venant’s Principle and Principle of Uniqueness

Introduction to Variational Calculus: The First Variation, Euler-Lagrange Equation, The Variational Notation, First Variation with Several Dependent Variables, Extremization under Constraints, Lagrange Multiplies, Kinematic and Natural Boundary Conditions, Functional with Higher Order Derivatives, Functionals With More Than One Independent Variable

Variational Principles of Elasticity: Virtual Work, The Method of Total Potential Energy, Complementary Virtual Work, Principal of Total Complementary Energy, Stationary Principles, Reissner's Principle, Castigliano Theorems; First Castigliano Theorem, Second Castigliano Theorem

Beams and Frames: Introduction, Technical theory of beams, Deflection Equation for the Technical theory of Beams, Justification for the theory of beams, Timoshenko Beam Theory, Use of Ritz method and Reissner Principle, Open frames and closed frames.

Torsion: Introduction, Total Potential Energy, Equation for Torsion, The total complementary energy functional, Approximate Solutions for Linear Elastic behavior, The Method of Trefftez and Kantorovich.

Theory of Plates: Kinematics of the Deformation of Plates, Stress Resultants Intensity Functions and Equations of Equilibrium, Minimum Potential Energy Approach, Principle of Virtual Work, Validity of Classical Plate Theory, Navier's and Levy's Methods.

Dynamics of Beams and Plates: Introduction, Hamilton's Principle, Equations of Motion for Vibrating Beams and Plates, Free Vibrations of a Simply supported Beam and Plates, Rayleigh's and Rayleigh-Ritz Method for Beams and Plates, The Timosenko Beam, The Eigen function and Eigen value Problems.

Elastic Stability: Introduction, Stability of rigid body systems, Elastic Stability of Columns and Elastic Stability of Plates, Approximation Methods with introduction to Finite Elements.

Text Books:

1. J N Reddy, An Introduction to Continuum Mechanics, Cambridge University Press, 2013.
2. Stephen Timoshenko, James Norman Goodier, Theory of Elasticity, McGraw-Hill, 1969.

Reference Books:

1. Dym, C. L. and Shames, I. H., Solid Mechanics: A Variational Approach, McGraw-Hill Book Company.
2. J.N Reddy, Energy Principles and Variational Methods in Applied Mechanics, John Wiley, 2^{nd} Edition.
3. Arthur P. Boresi, Ken P. Chong and James D. Lee, Elasticity in Engineering Mechanics, Third Edition, John Wiley & Sons, 2011.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : ***MET703***
Course Name : **Vibration Analysis and Control**
Credit (L-T-P) : **3 (3-0-0)**

OBJECTIVES

- Inculcate completeness in fundamentals of Engineering Mechanics which are left untouched during undergraduate program in mechanical engineering.
- Develop a complete base regarding mathematical modeling of engineering systems for vibration analysis.
- To make the student capable of solving field problems related to vibration.

If the student is interested, he should be capable of pursuing research in the area of advanced dynamics and vibration.

COURSE OUTCOMES

CO1: Confirm the understanding of basic terms, definitions and principles of vibration analysis.
CO2: Able to understand the general procedure to carry out Vibration analysis
CO3: Understanding of analysis methods for field problems
CO4: Able to solve vibration analysis problems using Approximate Methods
CO5: To understand the procedure of Transverse and longitudinal vibrations in different systems
CO6: To develop the understanding of Vibrations control
CO7: Learning Vibration experimental data measurement and its analysis

Syllabus

Fundamentals of Vibration: Basic concepts of Vibration, Vibration Analysis Procedures, Harmonic analysis, Free and Forced Vibration analysis of single degree of freedom system, Stability conditions, Methods of analysis, single degree of freedom systems with viscous, Coulomb and Hysteresis damping, Vibration under general forcing conditions.
Two Degree Freedom System: Introduction-Free and Forced Vibration Analysis of Undamped and Damped Systems, Bending Vibration of Two Degrees of Freedom System, Coordinate Couplings And Principal Coordinates, Stability Analysis.
Multi-Degree Freedom System and Continuous System: Far Coupled and Closed Coupled Systems, Generalized Coordinates and Generalized Forces, Lagrange's Equation, Eigen Value Problem, Orthogonality of Mode Shapes, Modal Analysis, Forced Vibration using Modal Analysis.
Numerical Methods: Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method, Myklestad-Prohl Method for Far Coupled Systems, Matrix Condensation Scheme, Component Mode Synthesis,
Continuous Systems: Transverse Vibration of a String or Cable, Longitudinal Vibration of a Bar or Rod, Torsional Vibration of a Shaft or Rod, Lateral Vibration of Beams
Vibration Control: Vibration Isolation, Vibration Absorbers, Static and Dynamic

Balancing- Balancing machines-Field balancing, Vibration Control by Design Modification,, Vibration as condition Monitoring tool

Vibration Measurement and Applications: Transducers, Vibration Exciters, Vibration Measuring Instruments, Signal Analysis, Experimental Modal Analysis, Machine Condition Monitoring and Diagnosis.

Text Books:-

1. Rao, S.S.,” Mechanical Vibrations,” Addison Wesley Longman, 1995.
2. J.S. Rao and K. Gupta, “Theory and Practice of Mechanical Vibrations”; New Age International Publishers

Reference Books:-

1. Textbook of Mechanical Vibrations; Rao V. Dukkipati, J. Srinivas, PHI Learning
2. Fundamentals of Vibrations; Leonard Meirovitch, Waveland Pr Inc.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : ***MET704***
Course Name : **Advanced Mechanical Engineering Design**
Credit (L-T-P) : **3 (3-0-0)**

Course Prerequisite:

The student should have studied mechanical engineering design and mechanics of solids.

Course Objectives:

The course objectives define the student learning outcome for the course. After completing the above course, student is expected to:

- Understand about types of mechanical engineering design failures.
- Understand about fatigue strength design and stiffness based design of machine elements
- Have knowledge about the design for creep, corrosion, wear and hydrogen embrittlement
- Gain knowledge about dynamic design of mechanical equipment's

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: Identify and analyze the various types of mechanical engineering design failures and theories of failures

CO2: Design the mechanical components based on fatigue and stiffness basis

CO3: Analyze and design the various mechanical components such as bearing, shafts, springs etc. for different applications for safe working

CO4: Recognize the requirement of lubrication system and dynamic design under varying load conditions of mechanical components.

Syllabus

Introduction to Advanced Mechanical Engineering Design. Review of materials & processes for machine elements. Case studies of mechanical engineering design failures. Review of static strength failure analysis -theories of failure including von-Mises theory based strength design. High cycle and low cycle fatigue. Fatigue Strength Design of Machine Elements. Exercises of fatigue design of shafting and gears. Surface fatigue design failures. Exercises of surface fatigue design of rolling contact bearings including linear bearings. Stiffness based design. Design for creep. Combined creep and fatigue failure prevention. Design to prevent buckling and instability. Tribo-design with applications to design of sliding bearings and mechanical seals. Selection of lubrication systems. Design for corrosion, wear, hydrogen embrittlement, fretting fatigue and other combined modes of mechanical failure. Dynamically sound designs of machine elements like springs and shafts. Introduction to dynamic design of mech. equipment and its implementation.

Books:

1. Norton L. R., “Machine Design – An Integrated Approach” Pearson Education, 2005

2. Fundamentals of Machine Component Design Robert C. Juvinall, Kurt M. Marshek, John Wiley & Sons

3. Maitra G.M., “Hand Book of Gear Design”, Tata McGraw Hill, 1985.

4. Joseph E. Shigley, Charles R. Mischke, Richard G. Budynas, “Mechanical Engineering Design”, McGraw Hill, 2004.

5. P.S.G. Tech., “Design Data Book”, Coimbatore, 2003.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : ***MET705***
Course Name : **CAD/CAE Lab**
Credit (L-T-P) : **2 (0-0-2)**

Course Description:

This course is aimed to provide hands-on practice to the students on computer-aided design (CAD) and computer-aided engineering (CAE) tools viz. Autodesk Inventor, Hypermesh. The course would include Solid (3D) Modeling of various machine components and their assemblies, creating 2D drawings-different views, including sectioned views - from 3D solid models using solid modeling software: Autodesk Inventor, and FE Analysis (structural, thermal, modal analysis, dynamic analysis) of basic mechanical structural elements using FEA software Hypermesh.

Course Outcomes:

Upon completion of this course the students will be able to

CO1: Execute steps required for 3D CAD modeling of various mechanical machine components and their assemblies created using protrusion, cut, sweep, extrude, etc. commands.
CO2: Create 2D CAD drawing - different views, sectioned views, isometric views, etc. - of 3D solid models of various mechanical machine components and their assemblies, with proper dimensioning and labeling; and would be able read and interpret various views of those created 2D CAD drawings.
CO3: Create finite element model - creating geometry, defining material properties, applying loading and boundary conditions, defining outputs, defining analysis, etc.- of basic mechanical structural elements using FEA software Hypermesh, and perform structural, thermal, modal analysis, dynamic analysis and interpret the results obtained.

Syllabus CAD

i) CAD Introduction.
ii) Sketcher
iii) Solid modeling –Extrude, Revolve, Sweep, etc and Variational sweep, Loft ,etc
iv) Surface modeling –Extrude, Sweep, Trim ..etc and Mesh of curves, Free form etc
v) Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc.
vi) Assembly-Constraints, Exploded Views, Interference check
vii) Drafting-Layouts, Standard & Sectional Views, Detailing & Plotting.

Exercises in Modeling and drafting of Mechanical Components - Assembly using Parametric and feature based Packages like Inventor / NX/ etc

CAE
Analysis of Mechanical Components – Use of Software like Hyperworks etc., Exercises shall include analysis of

i) Machine elements under Static loads

ii) Thermal Analysis of mechanical systems
iii) Modal Analysis
iv) Machine elements under Dynamic loads
v) Non-linear systems

Use of kinematics and dynamics simulation software like ADAMS, MATLAB. Analysis of velocity and acceleration for mechanical linkages of different mechanisms.

Course Materials/Books:

- Lecture notes and tutorials.
- "Mastering Autodesk Inventor 2012 and Autodesk Inventor LT 2012: An Autodesk Certified Official Training Guide By Curtis Waguespack.
- "Practical Aspects of Finite Element Simulation: A Student Guide 2012" certified official training guide by Altair- Hyperworks.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : ***MET706***
Course Name : **Vibration Lab**
Credit (L-T-P) : **2 (0-0-3)**

Course Outcomes

CO1: Detailed Description Of VFT.
CO2: Single Degree Of Freedom Undamped &Damped Spring-mass System.
CO3: Harmonic Excitations of Unbalance Rotor Shaft.
CO4: Lateral Vibrations Of Beam.
CO5: Cantilever Beam With Point Load and Spring.
CO6:Whirling Of Shaft.

Syllabus
Analysis of Mechanical Components – Use of FEA Packages like Hyperworks etc., Exercises shall include analysis of

i. Modal Analysis
ii. Non-linear systems
iii. Modal Analysis
iv. Machine Fault Simulator
v. Vibration control

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : ***MET707***
Course Name : **Mechanical Design Practice**
Credit (L-T-P) : **2 (0-0-3)**

Course Prerequisite:
The student should have studied basic courses of **Advanced Mechanical Design**

Course Description;

Mechanical machines are characterized by the fact that they have mobility and must move to perform their function. This differentiates mechanical engineering from other fields of engineering such as civil engineering in which structures are generally immobile. This course introduces the principles of machine component design, aided by the use of computer applications.

Course Objectives:
The practical course objectives define the student learning outcome for the course. After completing the above course, student is expected to:

1. Understand design process
2. Understand theories of failures
3. Understands design of various machine components
4. Understand design for creep, tribo, and corrosion.

Course Outcomes:
On successful completion of the course, the student will be able to:

CO1:Understand the fundamentals of the theories of failures
CO2:Apply failure theories to design machine components
CO3: Understand fatigue failure with creep, corrosion, etc.
CO4:Solve the iteratively using software Matlab.

Syllabus
Case studies of mechanical engineering design
failures Exercise of static failure theories
Exercise of fatigue failure
theories Design for Surface
fatigue
Design for fatigue design of shafting and gears.
Design for surface fatigue design of rolling contact bearings including linear
bearings. Design to prevent buckling and instability
Design for corrosion, wear, hydrogen embrittlement, fretting fatigue.
Tribo-design with applications to design of sliding bearings and mechanical
seals. Case studies.
Term Projects.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course Type : Program Elective
Course No. : *MET712*
Course Name : *Ad. Finite Element Methods*
Credit (L-T-P) : 3 (3-0-0)

Course Description: The Finite Element Method (FEM) has become a powerful tool for the numerical analysis of various problems in different areas of engineering and sciences. There are a host of applications including deformation and stress analysis of automotive, aircraft, building and bridge structures. FEM is also highly suitable for problems related to heat flux, fluid flow, magnetic flux and other flow problems. The great leaps with which computers have advanced and CAD systems have been simplified now enable complex problems to be modeled with relative ease. Several alternatives can be tried before a prototype is finalized without incurring the wastage of energy and material. The pre-requisite for this course is the knowledge of solid mechanics, elementary calculus and matrix algebra and ability to program in one of the computer languages such as MATLAB/FORTRAN. This course on FEM discusses all the important topics starting from fundamentals and mathematical modeling of one and two-dimensional problems to complex three-dimensional problems.

Scope: Fundamental concepts, matrix algebra and Gauss elimination, one-dimensional problems, trusses, two-dimensional problems using constant strain triangles, axisymmetric solids subjected to axisymmetric loading, two-dimensional isoparametric elements and numerical integration, beams and frames, three-dimensional problems in stress analysis, scalar field problems, dynamic considerations, pre-processing and post processing.

Course Objectives:

The course objectives define the student learning outcome for the course. After completing the above course, student is expected to:

- Understand physical principles and the mathematical modeling of engineering problems, and the basic theory of Finite Element Method (FEM).
- Do finite element modeling of engineering problems from various fields.
- Apply FEM to solve various engineering problems in solid mechanics, heat transfer and fluid mechanics.
- Create his/her own FEM computer programs, for simple problems, using a computer language, such as MATLAB/FORTRAN, and to have clear understanding of working of any FEM based commercial packages such as Hypermesh, ANSYS and ABAQUS

Course Outcomes:

Upon successful completion, students will have the knowledge and skills to:

CO1: Explain the basics theory of FEM and the general procedure to model and analyze an engineering problem using FEM.

CO2: Formulate FEM model of engineering problems from various fields defined in terms of mathematical form.

CO3: Apply FEM to solve various engineering problems in solid mechanics, heat transfer and fluid mechanics.

CO4: Develop FEM computer codes for simple problems using any computer language, and solve similar problems using any of the FEM based commercial packages such as Hypermesh, ANSYS and ABAQUS.Method for Engineers", Wiley Student Edition, Fourth Edition

Syllabus

General Introduction: Introduction- structural element and system- assembly and analysis of a structure- boundary conditions- general pattern- standard discrete system- transformation of coordinates- examples – direct physical approach to problems in elasticity- direct formulation- displacement approach – minimization of total potential- convergence criteria – discretization error- nonconforming elements and patch test- solution process- numerical examples

Generalization of Finite Element Concepts and Element Shape Functions: Boundary value problems – integral or weak statements- weighted residual methods- Galerkin method- virtual work as weak form of equations in solid and fluid mechanics- variational principles – establishment of natural variational principles for linear self-adjoint differential equations – standard and hierarchical elements- shape functions- rectangular elements- completeness of polynomials- Lagrange family- Serendipity family- rectangular prisms- tetrahedral elements- global and local finite element approximation- mapped elements- coordinate transformations- geometrical conformity of elements- evaluation of element matrices- transformation in $\xi, \eta \, and \zeta$ – coordinates-order of convergence- numerical integration –example problems

Unit-III: Applications to Field Problems: Solution to problems in linear elasticity- plane problems in elasticity- plates and shells- solution of problems in heat-transfer and fluid mechanics- numerical examples- discussion on error estimates

Unit-IV: Finite Elements in Structural Dynamics and Vibrations: Dynamic equations- stiffness, mass and damping matrices- consistent and diagonal mass matrices- Extraction of natural frequencies and modes- Reduction of number of degrees of freedom - modal methods - component mode synthesis- harmonic analysis- response history- explicit and implicit direct integration- stability and accuracy- analysis of response spectra- example problems

Non-linear Analysis: Non-linear problems in elasticity- some solution methods- plasticity: introduction, general formulation for small strains- formulation for von Mises theory- computational procedure- problems of gaps and contact- geometric non-linearity- modelling considerations

Text Book:

- T1. J. N. Reddy, An Introduction to the Finite Element Method, Tata McGraw-Hill Publishing Company Ltd., 3rd Edition, 2005, New Delhi.
- Reference Books:
- R1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall of India Private Limited, 3rd Edition, 2005, New Delhi.
- R2. P. Seshu, Text Book of Finite Element Analysis, Prentice Hall of India Private Limited, 2009, New Delhi.
- R3. O. C. Zienkiewicz, The Finite Element Method, TMH, New Delhi, 3rd Edition, 2002.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course Type : Program Elective
Course No. : *MET713*
Course Name : Optimization Methods in Engineering Design
Credit (L-T-P) : 3 (3-0-0)

Course Outcomes

CO1: To Create an Engineering design methodology using a mathematical formulation of a design problem to support selection of the optimal design among alternatives

CO2: Ability to apply the theory of optimization methods and algorithms to develop and for solving various types of optimization problems

CO3: Ability to solve the mathematical results and numerical techniques of optimization theory to concrete Engineering problems by using computer software

CO4: Write codes of optimization models using MATLAB

CO5: Analyse and examine the robustness of the solutions for the real world situations where input parameters are uncertain and cannot be estimated precisely

Syllabus

Unconstrained Optimization Techniques: Introduction to optimum design - General principles of optimization – Problem formulation & their classifications - Single variable and multivariable optimization, Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods – Interpolation methods.

Constrained Optimization Techniques: Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions, Lagrange multipliers - Geometric programming

Advanced Optimization Techniques: Multi stage optimization – dynamic programming; stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization.

Finite Element based Optimization: Shape Optimization, Topology Optimization

Static Applications:

Structural applications – Design of simple truss members - Design applications – Design of simple axial, transverse loaded members for minimum cost, weight – Design of shafts and torsionally loaded members – Design of springs.

Dynamic Applications: Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.

Books:

1. J S Arora ,"Introduction to Optimum Design" , Elsevier India Private Limited
2. Ashok D. Belegundu and Tirupathi R. Chandrapatula, "Optimization Concepts and Applications in Engineering"Cambrigde University Press, New Delhi

3. Rao, Singaresu, S., “Engineering Optimization – Theory & Practice”, New Age International (P) Limited, New Delhi, 2000.
4. Johnson Ray, C., “Optimum design of mechanical elements”, Wiley, John & Sons, 1990.
5. Kalyanamoy Deb, “Optimization for Engineering design algorithms and Examples”, Prentice Hall of India Pvt. 1995.
6. Goldberg, D.E., “Genetic algorithms in search, optimization and machine”, Barnen, Addison-Wesley, New York, 1989.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course Type : Program Elective
Course No. : *MET715*
Course Name : Composite Materials and Mechanics
Credit (L-T-P) : 3 (3-0-0)

Course Description:
Composite materials usually exhibit remarkable physical properties, in general superior to the properties of their individual components. They appear pervasively in engineering applications, e.g., reinforced concrete in construction, fiber-reinforced materials for aircraft and automotive structures, carbon reinforced composites in space and aircrafts, etc. Despite being comprised multiple material phases with different physical properties, these materials may be considered for practical purposes as homogeneous materials with physical material-like effective properties. The course will focus primarily on the elastic properties of a wide range of composites (laminated materials, particulate/fiber-reinforced composites, multidirectional laminates) and will cover a number of engineering methods for the computation of the effective properties of these materials based on the properties and spatial arrangement (volume fraction, shape, orientation, …) of their underlying constituents.

Course Outcomes:
At the end of the course the student will:
CO1: Have clear understanding of mechanical behaviour of layered composites compared to isotropic materials.
CO2: Be able to apply constitutive equations of composite materials and understand mechanical behaviour at micro, macro and meso levels.
CO3: Be able to determine stresses and strains in composites.
CO4: Apply failure criteria and critically evaluate the results.
CO5: Have understanding of the mechanical behavior of composites due to variation in temperature and moisture.

Syllabus
Introduction to Composite Materials Constituents, Material forms Processing, Applications Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.
Macromechanical and Micromechanical behavior of a lamina, Lamina Constitutive Equations:Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Q_{ij}), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness.
Macromechanical behavior of a laminate, Definition of stress and Moment Resultants, Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.
Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's

Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations. Orthotropic Lamina - special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates - Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates, Delamination, Matrix Cracking, and Durability, Interlaminar stresses, Edge effects, Fatigue and fracture, Environmental effects, Introduction to design of composite structures.

Books:

1. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.
2. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.
3. Hyer, M.W., "Stress Analysis of Fiber – Reinforced Composite Materials", McGraw- Hill, 1998.
4. Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press, 2006
5. Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press, 2006.

Mechanics of Composite Materials with MATLAB, G. Z. Voyiadjis, P. I. Kattan, Springer, 2005.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course Type : Program Elective
Course No. : *MET717*
Course Name : Rotor Dynamics
Credit (L-T-P) : 3 (3-0-0)

PREREQUISITE

Engineering Mechanics, Kinematics and Dynamics of Machines, Advanced Dynamics and Vibration

OBJECTIVES

Since industry as well as academia, both are short of engineers with a background of Rotor Dynamics, the course of this subject is designed focusing following objectives:

- To develop understanding to solve problems relating to vibration as cause of failure and catastrophe in rotating machines like turbine, compressor, turbocharger etc.
- Develop basic knowledge about rotor dynamics and becomes capable of doing mathematical modeling of various types of rotating systems.
- Student should be able to develop codes to arrive at accurate results in rotor dynamics.

If the student is interested, he should be capable of pursuing research in the area of rotor dynamics and nonlinear vibration.

Course Outcomes

CO1: TO develop the understanding about the vibrational phenomena occurred in rigid and flexible rotor disc systems

CO2: Able to understand different techniques of analysis to solve problems related to continuous rotor vibrations

CO3: To understand the procedure of static and transient response of systems under torsional vibrations

CO4: To develop the understanding and becomes capable to solve the pressure and nonlinear forces developed in fluid film bearing by constructing codes.

CO5: Able to understand the procedure and principle of general rotor disc phenomena like Whirling, gravity effects.

CO6: To develop the knowledge and capability to solve Rotordynamics field problems

Syllabus

Lateral Rotor Vibration Analysis: Simple linear 2 DOF model with only deflection motion, Inclination Vibration of an Elastic Shaft with A Disc at Its Center: Free Vibrations and Forced Vibrations, Vibrations of a 4 DOF Jefcott Rotor (Deflection motion and Inclination Motions coupled together), Vibrations of a Rigid Rotor, Balancing of a Rigid Rotor, Approximate Formulas for Critical speeds of a Shaft with Several Discs: Rayleigh's Method, Dunkerley's Formula

Vibrations of a Continuous Rotor: Transfer Matrix Analysis, Finite Element Method, Free Vibrations and Critical Speeds, Forced Vibrations, Balancing of a Flexible Rotor: Model Balancing Method, Influence Coefficient Method.

Torsional Vibrations in Rotating Machinery: Transfer Matrix Analysis for Free Vibrations, Transient Response in Torsional Vibrations, Branched Systems.

Rotors Mounted on Fluid Film Bearings: Mechanism of pressure development in the film, Reynold's equation, Journal Bearing, Steady state solution for a short bearing, A simple rotor in fluid film bearing, Transfer matrix analysis of rotors in fluid film bearings, Transfer matrix analysis of rotorsd by distributed elements, Optimum design of bearings for minimum unbalance response.

Shafts with Dissimilar Moments of Inertia: Whirling of shaft with dissimilar stiffness, Effect of disk unbalance, Effecty of gravity on a balanced disk, transient response by a time marching scheme.

Condition Monitoring Using Vibration Measurements: Vibration generating mechanisms, Condition monitoring, Noise Specturm, Real time analysis, Applications of FFT Rotor Vibrations.

Text Books:-

1. Rotor Dynamics; J.S. Rao, New Age International Publishers.
2. Linear and Nonlinear Rotor Dynamics; Toshio Yamamoto, Yukio Ishida , John Willey and Sons Inc.

Reference Books:-

3. Handbook of Rotordynamics; Fredric F Ehrich, Willey, 1998.
4. Machinery Vibration and Rotordynamics; John M. Vance, Fouad Y. Zeidan, Brian G. Murphy, Willey, June, 2010.

Online/E resources:-

1. **https://nptel.ac.in/courses/112/103/112103024/**
2. **https://www.cadfem.net/in/en/shop/professional-development/training-elearning/rotor-dynamics-dynamic-simulation-of-rotating-structures-13634.html**
3. **https://www.vi-institute.org/the-eshleman-foundation/practical-rotor-dynamics-modeling**

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course Type : Program Elective
Course No. : *MET720*
Course Name : Fracture Mechanics
Credit (L-T-P) : 3 (3-0-0)

Course Outcomes

CO1: To introduce the student to the concepts of failure of materials with pre-existing cracks and flaws.
CO2: To understand the methodologies of calculation of fracture mechanics parameters and design based on fracture mechanics.
CO3: Ability to solve the mathematical results and numerical techniques of Fracture Mechanics to concrete Engineering problems by using computer software.
CO4: To familiarize with the methodology of resolution of problems and be able to apply fundamental concepts of fracture mechanics to practical design problems.
CO5: To develop the students understanding on the design principle of materials and structures using fracture mechanics approaches.

Syllabus

Introduction: Kinds of failure and history Conventional failure criteria, Characteristic brittle failures, Griffith's work, Fracture mechanics, Dilemma of Griffith, Surface energy, Griffith's realization, Griffith's analysis, Mathematical formulation, Thin plate vs thick plate Critical energy release rate.
Stress intensity factor (SIF): Linear elastic fracture mechanics (LEFM), Stress and displacement fields in isotropic elastic materials, Elementary properties of complex variables
SIF of more complex cases: Application of the principle of superposition, Crack in a plate of finite dimensions, Edge cracks, Embedded cracks, Relation between G_I and K_I
Anelastic deformation at the crack Tip: Further Investigation at the crack tip, Approximate shape and size of the plastic zone, Effective crack length, Effect of plate thickness.
Elastic plastic analysis through J-Integral: Relevance and scope, Definition of J-Integral, Path independence, Stress-strain relation.
Crack tip opening displacement (CTOD): Relationship between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J.
Test methods K_{IC} test techniques, Test methods to determine J_{IC}, Test methods to determine G_{IC} and G_{IIC}, Determination of critical CTOD.
Fatigue failure: Terminology, S-N curve, Crack initiation, Crack propagation, Effect of an overload, Crack closure, Variable amplitude fatigue load.
Mixed mode crack initiation and growth: Fracture surface, Mixed mode crack propagation criteria, Crack growth.
Crack detection through NDT : Visual, LPI, Magnetic Methods, Radiography, Ultrasonics.

Books:

1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.
2. T .L . Anderson, FractureMechanics - Fundamental s and Applications, 3rd Edition, Taylor and Francis Group, 2005.

D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic, Publishers, Dordrecht , 1986.

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course Type : Program Elective
Course No. : *MET721*
Course Name : Design Of Mechanisms
Credit (L-T-P) : 3 (3-0-0)

Course Prerequisite:
The student should have studied basic courses of **Kinematics and Dynamics of Machines**.

Course Description;
Mechanical machines are characterized by the fact that they have mobility and must move to perform their function. This differentiates mechanical engineering from other fields of engineering such as civil engineering in which structures are generally immobile. This course introduces the principles of designing mechanisms, aided by the use of computer applications. Students will investigate the kinematics and dynamics of machinery. Topics include fundamentals of linkage kinematics and dynamic design.

Course Objectives:
The course objectives define the student learning outcome for the course. After completing the above course, student is expected to:

1. Understand existing mechanisms used in the real mechanical machines and devices
2. Understand various types of mechanisms and linkages
3. Understands graphical, analytical and computer software to analyze and design
4. Understand the fundamentals of the theory of kinematics and dynamics of machines
5. Understand synthesis of mechanisms

Course Outcomes:
On successful completion of the course, the student will be able to:

CO1: Understand the fundamentals of the theory of kinematics and dynamics of machines

CO2: Analyze the motion characteristics of the machine analytically, graphically or computationally

CO3: Dynamic analysis and Balancing

CO4: Synthesize mechanisms according to motion requirement

Syllabus
Study of existing mechanisms used in industry, machine tools, vehicles, high speed machinery. Classification of mechanisms. Structural analysis and synthesis for conceptual design. Theory of path curvature and finitely movements. Kinematic and dynamic design. Spatial Mechanisms. Errors in mechanisms and machines. Coding, evaluation and dimensional synthesis of mechanisms.

Books for Reference:

1. Mechanism Design: Analysis and Synthesis, Vol. I & II, A.G. Erdman and G.N. Sandor, Prentice-Hall
2. Geometric Design of Linkages, J.M. McCarthy, Springer
3. Kinematic Synthesis of Linkages, R. S.Hartenberg, and J Denavit,., McGraw-Hill
4. Kinematics and Dynamics of Machinery, R.L. Norton, McGraw Hill Education (India) Pvt Ltd

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : *MES741*
Course Name : Seminar
Credit (L-T-P) : 4 (0-0-4)

Course Objectives:

♣ To have a practical understanding of mechanical engineering systems through the application of the acquired knowledge, skills and tools.

♣ To promote development of intellectual property by publishing articles in journals, conference proceedings, patents.

Course Outcomes:

On successful completion of the course, the student will be able to:

CO1: To do literature survey on the chosen topic

CO2: To organize the material

CO3: To deliver well-organized technical presentations at conferences and other symposia

CO4: Able write a review paper

Malaviya National Institute of Technology ,Jaipur

Mechanical Engineering Department

Course No. : *MED793*
Course Name : Dissertation
Credit (L-T-P) : 16(0-0-16)

Course Prerequisites:

The students should have studied the basic course of production engineering

Course Description:

The course aim is to enable students to develop an understanding and obtain practical experience of the research process and research skills required to undertake a supervised research project.

Course Objectives:

The aim of this course is:

1. To enable students to learn practical aspects of research.

2. To prepare students in production engineering in the writing of their final semester research proposals, with emphasis on research problems, hypotheses, literature review and research designs. 3. To develop research skills commensurate with the accomplishment of a master's degree

Course Outcome:

After successful completion of this course, students will be able to:

CO1: Identify a problem in area of production engineering.

CO2: Review literature to identify gaps and develop research methodology.

CO3: Develop a model, experimental set-up and/or computational techniques necessary to meet the objectives.

CO4: Prepare a report as per the recommended format and defend the work & Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.